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transistor mutual and self inductance bridge

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MP MASTER

MA23809

handbook

MUTUAL AND SELF

INDUCTANCE BRIDGE

(Cat. No. 1854)

Handbook No. 163

Further copies of this handbook
may be purchased on application
to the Service Manager.

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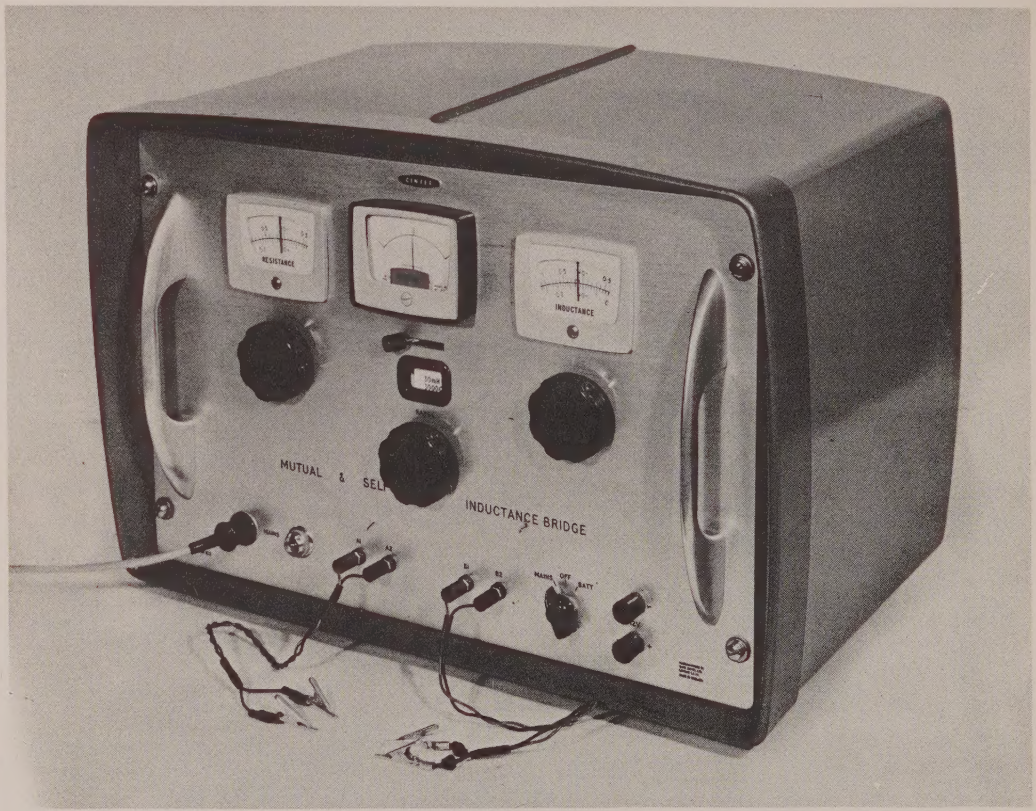

FRONTISPIECE

GENERAL VIEW OF INSTRUMENT

SHOWING FRONT PANEL CONTROLS

AND FIBREGLASS CASE

AMENDMENTS TO HANDBOOK 163
MUTUAL & SELF INDUCTANCE BRIDGE (CAT. NO. 1854)

Amendment No. 1 - Page 18

Delete: Dimensions

$14\frac{1}{2}$" x 21" x $12\frac{1}{2}$"
(36·8 x 53·3 x 31·8cms)

Insert: Dimensions

$20\frac{1}{2}$" wide x 13-3/4" high x 12-3/4" deep
(52·1cm x 34·9cm x 32·4cm)

Amendment No. 2 - Components for Figure 8

Delete: All components under the heading CAPACITORS.

Insert: CAPACITORS

C1	0·005μF	1000V	PAPER	
C2	(75-400pF		TP12/D	CYLDON
	(10-110pF		TP1/D	CYLDON
C3	10-110pF		TP1/D	CYLDON
C4	(75-400pF		TP12/D	CYLDON
	(10-110pF		TP1/D	CYLDON
C5	75-400pF		TP12/D	CYLDON
C6	75-400pF		TP12/D	CYLDON
C7	75-400pF		TP12/D	CYLDON
C8	(75-400pF		TP12/D	CYLDON
	(10-110pF		TP1/D	CYLDON
C9	10-110pF		TP1/D	CYLDON

CONTENTS

	Page
INTRODUCTION	1
PRINCIPLE OF OPERATION	3
OPERATING INSTRUCTIONS	
To Measure Self Inductance or Resistance	7
To Measure Mutual Inductance . .	9
CIRCUIT DESCRIPTIONS	
Inductance Bridge.	11
Bridge Amplifier	12
Oscillator & Driver Unit . . .	13
Reference Signal Circuit . . .	13
Phase Discriminator	14
Power Unit	15
MISCELLANEOUS DETAILS	
Ranges	17
Transistors & Rectifiers . . .	18
Power Consumption	18
Dimensions	18
TEST SPECIFICATIONS	19
PARTS LIST	

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LIST OF ILLUSTRATIONS

Figure

1 Basic Circuit

2 Basic Circuit With 'Unity-Ratio' Transformers

3 Basic Circuit With 'Step-up' Transformers

4 Simplified Circuit of Instrument

5 Connections to 'Self Inductance'

6 Connections to 'Resistance'

7 Connections to 'Mutual Inductance'

8 Circuit of Inductance Bridge

9 Circuit of Bridge Amplifier

10 Circuit of Oscillator & Driver Unit

11 Circuit of Phase Discriminator

12 Circuit of Power Unit

Sketch

A Amplifier Test Circuit (page 21)

B Phase Discriminator Test Circuit (page 23)

INTRODUCTION

This audio-frequency bridge is designed for the accurate measurement of low mutual or self inductance in the range 0·001 microhenry to 30 millihenries. Provision is also made for the measurement of series resistance.

The instrument enables rapid and accurate measurements to be made on coils having a low 'Q' value at audio frequencies, such as the tuning coils used in radio and television receivers. It may also be applied in the measurement of correcting inductances, loading coils, transmission line impedances and circuit 'strays'. This latter application is particularly useful in the testing of high frequency circuits.

The bridge can be conveniently used for the setting-up of artificial transmission lines, each section being treated as a three terminal network. Mutual resistance can also be measured and the bridge may be used for the measurement of low resistance values, the lowest calibrated value being 100 microhms.

PRINCIPLE OF OPERATION

The principle upon which the bridge operates is illustrated in Figure 1. A high-impedance generator G supplies a circuit comprising an unknown impedance Zx connected in series with an adjustable negative impedance -Z. If the value of -Z be made equal to the impedance of Zx, the circuit will have zero impedance and the detector D will show a null reading.

This basic circuit is inconvenient for certain reasons and it is advantageous to make connexion to the unknown impedance by way of transformers, which may be of unity ratio, as shown in Figure 2. With this arrangement the range of measurement cannot exceed the range of adjustment of the balance component -Z.

To extend the range, the ratios of both transformers may be changed from unity, as illustrated in Figure 3. The impedance Zx of the unknown is then related to the magnitude of the variable impedance -Z at balance (which may be written as Zb) by the equation

$$Zx = n.m.Zb$$

where 1 : m is the turns ratio of the current transformer interposed between the generator and the unknown impedance and n : 1 is the ratio of the voltage transformer interposed between the unknown impedance and the detector.

In practice the adjustable balancing impedance has separately-variable inductive and resistive components, and

the detector may be made sensitive only to the resistive or to the inductive component of the voltage applied to it from the bridge, so that the two balances are only slightly inter-dependent.

Figure 4 illustrates the basic circuit of the actual instrument. Current from the output transformer T1 of the generator is fed to the primary winding of a current transformer T2, which has connected in series with it the primary winding of the mutual inductor L1 and the slide wire VR1 and the resistor R2. Current induced in the secondary winding of T2 flows through the unknown impedance Zx.

The voltage drop across Zx is applied to the primary of a potential transformer T3, whose secondary is connected in series with the secondary of transformer T4 and resistor R2.

The sense in which the secondary windings of mutual inductor L1 and transformer T4 are connected to the secondary of T3 is such that the inductive and resistive components of voltage are induced in the secondary circuit of L1 in opposition to those from T3, i.e. the transferred impedances appear as negative. Thus potentials transferred to the secondary winding of T3 are balanced against those derived from L1 and VR1 (via T4), which are adjusted until detector D indicates their equality by a null reading.

A phase-sensitive detector is employed, which can be switched to respond only to the resistive or to the inductive component of voltage applied to it. This arrangement renders the resistance and inductance balances substantially

independent of each other.

The resistance of R2 appears in the secondary circuit as a negative mutual resistance and is provided to ensure that the zero of the resistance scale is not at the end of the slide wire. This arrangement avoids the difficulty of reaching a true zero point because of wiring resistance external to the slide wire itself.

OPERATING INSTRUCTIONS

To measure Self Inductance or Resistance

(1) Connect the coil or resistor to be measured to the four terminals as shown in Figure 5 or Figure 6.

Note that the four-terminal method of measurement employed enables the resistance and inductance of the connecting leads to be ignored, provided that they are not excessively long.

When a very low resistance, such as a short length of resistance wire, is to be measured the leads should be connected as shown in Figure 6 thus avoiding inaccuracies due to lead or contact resistance. The resistance actually measured is the resistance between the connexions of the potential leads from the B terminals, as indicated at 'R'. If long leads are required to connect the unknown to the bridge, these should be twisted in pairs, A1 with A2 and B1 with B2. The A1 and B1 leads must be taken to the same terminals of the unknown or the impedance will appear as negative.

(2) Set the RANGE SWITCH to 30mH.

(3) Operate the key switch to the left, that is to BALANCE RESISTANCE.

(4) Balance meter reading to zero by adjustment of the RESISTANCE dial, turning the control in the direction in which the meter needle must move to the zero point.

(5) Operate the key switch to the right, that is to BALANCE INDUCTANCE.

(6) Balance meter reading to zero by adjustment of the INDUCTANCE dial.

(7) Repeat operations (3) to (6). If the inductance being measured is greater than 30mH it is beyond the range of the bridge and balance cannot be obtained. If it is less than 30mH and more than 10mH, an accurate balance may be made on this range. If, however, the value, is less than, say 3mH, the setting of the Inductance dial will be near zero and the highest accuracy will not be attained. To find the correct range, turn RANGE switch two or three steps anti-clockwise and re-balance (operations (3) to (6)). If the point of balance is still near zero, rotate the range switch still further until a range is found at which a satisfactory balance can be found.

This full procedure is necessary only when it is impossible to guess the approximate value of the inductor. It is generally possible to distinguish whether a component will have an inductance in the millihenry or microhenry range by its appearance, and a start may be made with the range switch in a more appropriate position. If any difficulty is found the full procedure given above will always give the correct result.

It is advised that the operator spends a few minutes practising with various values of inductance. In this way he will 'get to know' the bridge and will find balancing a very simple operation.

To Measure Mutual Inductance

(1) Connect the Coils to the four terminals as shown in Figure 7.

(2) Balance bridge exactly as for a self-inductance (operations (2) to (7) above). Note that it is possible to obtain a NEGATIVE mutual inductance. If a balance is obtained on a negative dial reading reverse the connecting leads to ONE ONLY of the coils. In this case the RESISTANCE dial indicates Mutual Resistance which will in most cases be zero.

CIRCUIT DESCRIPTIONS

Inductance Bridge (FIG. 8)

The ratio of transformer T1 whose secondary feeds current through the unknown impedance via terminals A1-A2, is varied according to the range of measurement required by means of two banks S2/b and S2/a (range switch). S2b alters the secondary connexions to the unknown for each decade range, while S2/a connects the input from the Oscillator and Driver Unit to either the whole or to one third of the primary winding of T1 to provide the 'x3' ranges interpolated between the 'x10' ranges.

Connected across the source in series with the primary of T1 are the primary winding of the mutual inductor L1, the slide wire VR2 and resistor R2; the voltage appearing across the tapped portion of VR2 is applied to the primary of transformer T3, whose secondary winding is connected in series with the secondary winding of L1, giving the effect of negative resistance as explained on page 4.

The effective value of resistance required, to accord with the mutual inductor employed, is 12Ω. This is an inconvenient value, as it is too low for a normal potentiometer type component and too high for a slide wire of normal construction. This difficulty is overcome by the use of a 2Ω slide wire in conjunction with transformer T3, which is given a step-up ratio of 6·3 1 and therefore transfers the voltage drop across this resistor to the secondary circuit, so that it appears equivalent to the drop across a 12Ω resistor.

VR1 in shunt with the slide wire enables it to be adjusted to the required effective resistance of 2Ω so that the scale calibration is correct.

Resistor R2 is common to both primary and secondary circuit and the connexions of transformer T3 are such that it appears as a negative mutual resistance whose purpose has already been explained.

Voltages appearing across the unknown impedance by reason of the current fed through it are applied through terminals B1-B2 to the primary winding of potential transformer T2 via range switch S3/C. The primary winding is shunted by one of the trimming capacitors C2-C9 (selected by S3/d) which are provided to compensate for the variation in effective leakage reactance in T2.

Bridge Amplifier (FIG. 9)

The signal from the Inductance Bridge appearing across the secondary of transformer T2, the secondary of L1 and the mutual resistance components (figure 8) in series, is applied to pin 7 of the Amplifier Unit. This signal is then amplified by the three stage R-C coupled amplifier comprising TRN1, TRN2 and TRN3. The response of this amplifier is arranged to fall off rapidly on either side of the oscillator frequency to prevent trouble from hum-pickup or response to harmonics of the oscillator.

The collector load of TRN3 is the primary of T3, figure 11, and the output of this transformer is fed to the Phase Discriminator.

The key switch S3a, figure 8, is connected between pins 4 and 5 of the amplifier and, when closed, places R11 across R9. The purpose of these two values of collector load resistor for TRN2 is to achieve approximately equal sensitivity on resistance and inductance balance.

Oscillator & Driver Unit (FIG. 10)

The frequency of oscillation, as determined by the parallel combination of L1 with C3 and C4 in series, is set at 1592c/s, but can be varied ±10c/s by adjustment of L1. This set frequency is chosen as it corresponds to an angular frequency of 10 000 radians per second, which is convenient for reactance calculations.

The operation of the complete circuit, comprising L1, C3, C4 and TRN1 is similar to that of the Colpitts oscillator. The output buffer, TRN2, has its base directly coupled to the emitter circuit of TRN1, thereby deriving d.c. bias, in addition to the signal voltage, from this point.

The large amount of negative feedback due to R6, in the emitter of TRN2, ensures minimum loading on the oscillator, as well as a constant current drive to the output transformer T1. Thus a constant current drive is applied to the inductance bridge (figure 8) via pins 8 and 9, and a signal is applied to the reference signal circuit (figure 11) from a low impedance source via pin 4.

Reference Signal Circuit (FIG. 11)

An output is taken from the oscillator driver via pin 9 to the base of TRN1. The signal appears across

the primary of T1, emitter load, which has in its secondary circuit a phase-shifting network.

This network is adjusted to provide signals differing in phase by 90° and the circuit is so arranged that operation of S3, figure 8, applies to transformer T2, via emitter follower TRN2, a voltage either in phase with the voltage derived from the bridge amplifier when a pure resistance is being measured, or 90° lagging with respect to this voltage for inductance measurements. VR1 and VR2 (Detector Phase) adjust the voltage phases individually for ease of setting up and greater accuracy.

Phase Discriminator (FIG. 11)

The balanced secondary winding of transformer T2 feeds the anodes of diodes MR1 and MR2 with a voltage which is either in phase with the resistive component of the signal voltage, applied to the detector from the bridge amplifier, or 90° lagging with respect to this component. To the centre tap of the secondary winding of T2 is applied the output from the Bridge Amplifier, which is thus added to the voltages induced in each half of the secondary winding and applied to the anodes of the diodes.

Any component in the output of the bridge amplifier which is in phase with the voltage applied from T2 to one diode will be 180° out-of-phase with the voltage applied to the other diode, hence it will produce an out-of-balance condition in the voltages appearing across diode loads R8 and R9. On the other hand, any voltage component which is 90° out-of-phase with the voltages in T2 will effect both diodes equally and will not produce an out-of-balance component. Thus only that component of output voltage from

the bridge amplifier which is in phase with the voltage selected by S3, figure 8 will affect the balance meter.

The d.c. voltages appearing across the load resistors R8 and R9 of the diodes MR1, MR2 are applied directly to the centre zero meter. This meter indicates zero when the diode cathode potentials are equal. The direction of meter deflexion on unbalance is arranged to indicate the direction of movement of the balance control required to obtain balance; a left hand deflexion of the meter requires a clockwise rotation of the balance control to restore it to zero and vice-versa.

R6 and R7 ensure that the maximum unbalance in the voltages at the diode cathodes cannot exceed that required for maximum deflexion of the balance meter, so that overloading of the meter is impossible.

Power Unit (FIG. 12)

The power supplies for the instrument can be obtained either from the mains, after rectification and smoothing, or direct from a 12V battery supply. The primary of transformer T1 is tapped to accept mains supplies of 110-120V and 200-250V at 50-60c/s and fused by F1.

With the instrument switched to accept mains, the input is on pins 6 and 7 and feeds via the appropriate tapping points PL1 and PL2 to the primary of T1. The secondary of T1 feeds MR1 and MR2 to provide full wave rectification; the resultant d.c. being smoothed by C1 and R1. ZD1 and ZD2 provide stabilization by keeping a constant voltage drop with variations of load current.

For an easier understanding of the switching and fusing, reference should be made to figure 8. With the MAINS/ BATT. selector switch S1, figure 8, set to MAINS, the supply is fed via an indicator lamp LP1 (and R1) to the primary of T1, figure 12. Switch banks S1c and S1d short pin 1 to pin 4 and pin 2 to pin 3 respectively, while the -12V output is taken between pins 3 and 5 and fused by F2.

With selector switch S1 set to BATT., 12V d.c. is fed direct to pins 3 and 4. The output is once more taken via pins 3 and 5 and fuse F2.

MISCELLANEOUS DETAILS

Ranges

The calibrated range of mutual and self inductance extends from 0·001 microhenry to 30 millihenries and the resistance range from 1 microhm to 3000 ohms. Full accuracy is obtained upwards from 0·03 microhenry and 3 milliohms respectively. Both ranges are covered in twelve steps, the maximum reading on each step being greater than that on the step below by alternate multiples of 3 and 10 so that it is never necessary to use the lower and less accurate portion of the scale to obtain balance. On the lowest four ranges the full accuracy may not be obtained when measuring an inductance of very low 'Q', i.e. a truly non-inductive resistor may show some reactive component, but the resistance will be accurately measured.

The accuracy of the measurement is ±1% of the full-scale reading on all ranges. The actual ranges obtained for each of the twelve settings of the range switch are as follows:

Inductance (Full scale)	Resistance (Full scale)
0·1μH	·01Ω
0·3μH	·03Ω
1·0μH	·1Ω
3·0μH	·3Ω
10μH	1Ω
30μH	3Ω
100μH	10Ω
300μH	30Ω

Inductance (Full scale)	Resistance (Full scale)
1·0mH	100Ω
3·0mH	300Ω
10mH	1000Ω
30mH	3000Ω

Transistors

7 - GET 114

Rectifiers

2 - OA 81
2 - SX 62
2 - OA 10

Power Consumption

Battery - 12V 10mA
Mains - 240V 25mA (6VA)

Dimensions

$14\frac{1}{2}$" x 21" x $12\frac{1}{2}$"
(36·8 x 53·3 x 31·8cms)

TEST SPECIFICATION

1. POWER UNIT 31C/3947 (FIG. 12)

(a) Insert a 1·5kΩ $\frac{1}{2}$W ±5% resistor between pins 1 and 2.

(b) Connect the mains supply, via a variac, to pins 6 and 7.

(c) Set the mains transformer tapping panel to 240V.

(d) Switch the mains 'on' and adjust the variac to give 240V. Measure the voltage between pins 1 and 2, pin 2 being positive. This should be between 9·5V and 15V.

(e) Check that the ripple between pins 1 and 2 is not greater than 8mV p/p.

(f) Measure the ripple across C1 with its positive side earthy. This should not be greater than 2V p/p.

(g) Adjust the variac ±20V and check that the output voltage does not vary by more than ±$\frac{1}{2}$%. Also check that the output ripple does not increase.

(h) Set the variac to 240V and measure the a.c. voltages between '0' and the other tapping panel voltage tags. Check that the voltages are within ±2% of the values marked on the panel.

(j) With all tests completed, remove the 1·5kΩ resistor from pins 1 and 2.

2. OSCILLATOR & DRIVER UNIT 31C/3943 (FIG. 10)

(a) Connect 12V d.c. between pins 1 and 2, pin 2 being positive.

(b) Switch on and measure the current in the negative line. This should be between 1·2mA and 1·8mA.

(c) Connect an A.F.M. between pins 4 and 2, pin 2 being earthed. Adjust the frequency of the oscillator unit, by means of the coil (L1) adjustment, to 1592c/s. Check that the frequency control varies ±10c/s about this point and reset to 1592c/s.

(d) Disconnect the A.F.M. and connect an oscilloscope in its place between pins 4 and 2. Check that the output amplitude is between 6V and 8V p/p. Check also, that a good sine-wave is obtained with no apparent flattening or distortion.

(e) Insert a 22Ω $\frac{1}{2}$W ±5% resistor between pins 8 and 9 and measure the output amplitude across the resistor. This should be between 95mV and 115mV p/p.

(f) Check that the d.c. between pins 4 and 2, with pin 2 positive, is between 3·5V and 4·5V.

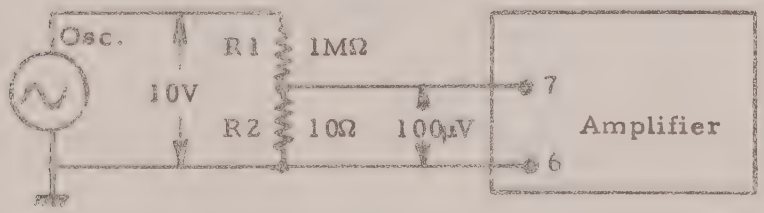
(g) Remove the 22Ω resistor from pins 8 and 9 when the tests are completed.

3. AMPLIFIER UNIT 31C/3941 (FIG. 9)

(a) Insert a 4·7kΩ $\frac{1}{2}$W±5% resistor between pins 2 and 4.

(b) Connect 12V d.c. to pins 1 and 4 with pin 1 positive.

(c) Connect the amplifier to a test oscillator as shown in sketch A. Adjust the output of the oscillator to 10V p/p at 1·5kc/s so as to obtain 100μV p/p input to the amplifier.



Sketch A.

Note: It is possible to use the oscillator unit for this test by adjusting the values of R1 and R2 to give 100μV input to the amplifier with 6V to 8V output from the oscillator unit. With R2 = 10Ω, then R1 = Vosc x 10^5Ω.

(d) Connect an oscilloscope between pins 2 and 1 with pin 1 earthed.

(e) Switch 'on' and measure the current in the negative line. This should be between 2mA and 3mA.

(f) Check that the output of the amplifier, measured on an oscilloscope, is greater than 2V p/p.

(g) Check that with the 100μV input, the output is undistorted.

(h) Check the response of the amplifier:

(i) flat from 1·5kc/s to 3kc/s within ±5%.

(ii) at least 30% down at 500c/s and 10kc/s.

(j) Remove the 4·7kΩ resistor after test.

4. PHASE DISCRIMINATOR 31C/3945 (FIG. 11)

(a) Connect pin 7 to pin 11.

(b) Connect a 100-0-100μA meter to pins 13 and 12 with pin 12 positive.

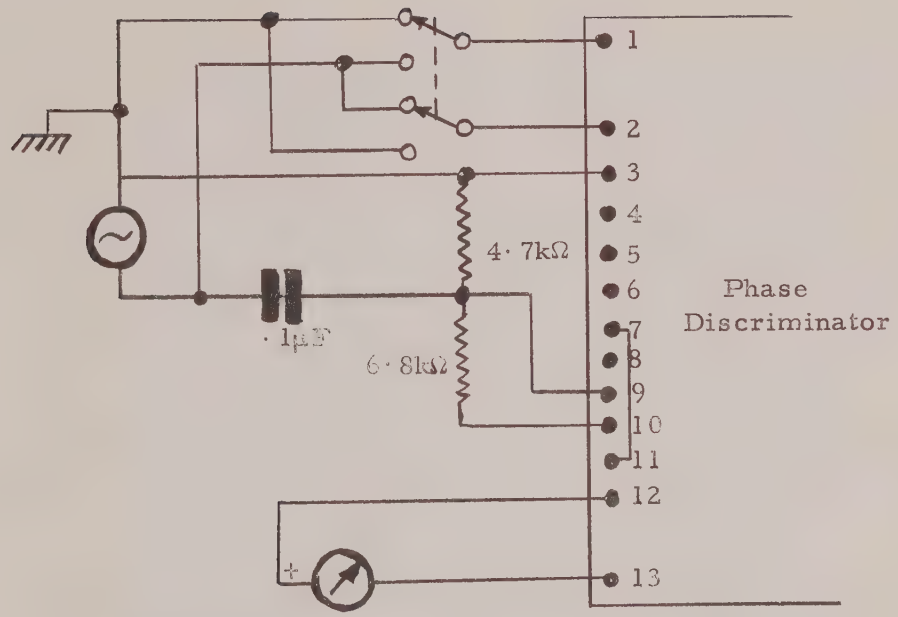
(c) Connect a 6·8k $\frac{1}{2}$W ±5% resistor across pins 10 and 9 and a 4·7k $\frac{1}{2}$W ±5% resistor across pins 3 and 9.

(d) Connect a test oscillator via a 0·1μF capacitor to pin 9 and to earth, pin 3. Also connect the oscillator direct to pin 1 and pin 2 via a changeover switch (see sketch B).

(e) Connect 12V d.c. to pins 3 and 10, with pin 3 positive.

(f) Switch on the 12V supply and measure the current in the negative line. This should be between 3·8 and 4·4mA.

(g) Set the frequency of the oscillator to 1·6kc/s and adjust the output amplitude to obtain full-scale deflection on the meter. The output amplitude of the oscillator should be between 5·3V and 6V p/p.



Sketch B

(h) Reverse the connections to pins 1 and 2 and check that the meter swings with the same deflection in the opposite direction.

Note: If a large difference in deflection is obtained, change MR1 or MR2 or both, or C6 or C7 or both. In extreme cases a diode and a capacitor may require changing.

(j) Check that the d.c. voltage at pin 4 is between 3·8V and 4·4V.

(k) Check that the a.c. signal at pin 7 is between 2·2V and 2·7V p/p.

(l) Remove all links, resistors etc., after test.

5. INDUCTANCE BRIDGE 31C/3951 (FIG: 8)

(a) Connect 12V d. c. to the equipment.

(b) Check the frequency of the oscillator unit and, if necessary, adjust to 1592c/s.

(c) Join A1 to A2 and B1 to B2 by means of the crocodile clips on the ends of the leads. Lay the pairs of test leads as far apart as possible.

(d) Balance the bridge for inductance and resistance by loosening the dials from the shafts and rotating the shafts of the slide wire and inductometer.

Check that at balance the inductor rotor is in the 9 o'clock position, approximately, when viewed from the front. With the bridge balanced, set the dials to zero and tighten them onto the Shafts.

(e) Switch S3 to 'inductance' and rock the resistance dial. Adjust VR2 on the phase discriminator, figure 11, until there is minimum movement on the meter. Switch S3 to 'resistance' and rock the inductance dial. Adjust VR1 on the phase discriminator until there is minimum movement on the meter. Repeat this procedure until the controls are relatively independent of each other.

(f) Setting Trimmer Capacitors

The purpose of these components C2 to C9 is to

avoid false readings of inductance when measuring a substantially non-inductive resistor. The procedure is as follows:

Balance the bridge on the particular range with the leads set-up as described in (c). Connect a non-inductive resistor of approximately 80% of the full-scale reading to the leads and re-balance the resistance dial. Check the inductance range and, if wrong, adjust the appropriate capacitor (C2 - C9) to bring the bridge into balance.

If the maximum value of the trimmer is too small for some ranges, C1 may be decreased, but not below ·001μF. Should this be found necessary, check the wiring etc., of the ratio transformers. Once all the ranges have been adjusted they should be rechecked and adjusted, if necessary, until correct balance is obtained.

(g) Set the range switch to 30mH and balance the bridge for zero with the leads set-up as in paragraph (c).

With the bridge balanced, rotate the range dial through all the ranges and check that there is no appreciable zero error on inductance or resistance.

(h) Setting Inductance Dial

Check that the inductance stator is parallel with

the rotor over 360°. If this is not so, adjust by using a 20 s.w.g. shim.

Balance the bridge to zero with the leads as in (c), slacken the dial and adjust so that zero is in line with the cursor. Tighten the dial and check the reading. Connect a 100-1000μH standard to the test leads with the B1 and B2 clips inside the A1 and A2 clips. Check the dial at 1000, 600 and 300μH. If the readings do not coincide with these values the stator of the inductometer will have to be adjusted by means of the nuts provided. If the readings are too low the spacing between stator and rotor will have to be increased and if high the spacing requires decreasing.

After making adjustments re-check zero and other points. Switch to the 300μH range and check at 100, 200 and 300μH. The errors between the two ranges should be meaned out by adjustment of the rotor/stator relationship if necessary.

With the range switch at 1mH, check the linearity of the scale in 100μH steps. At no place must the inaccuracy exceed 1% of full scale.

Check all ranges at 1/3, 2/3 and full scale when standards are available.

(j) Setting Resistance Dial

Balance the bridge for zero with the leads set up

as in (c). Slacken the dial and adjust so that zero is in line with the cursor. Tighten the dial and recheck the reading.

Connect a 0-1kΩ standard to the test leads with the B1 and B2 clips inside the A1 and A2 clips. On the 10mH range, balance the bridge and adjust VR1 (Figure 8) until the reading is correct. Recheck at zero.

Check the dial in 100Ω steps and adjust VR1 if necessary until any errors are meaned out over the whole range. Check on the 300μH range in 50Ω steps. It may be necessary to adjust VR1 to mean out the errors between ranges and the linearity of the ranges.

Spot check on all ranges at full- and half-scale where possible. Errors must not exceed 1% of full scale.

(k) Recheck paragraph (e).

(l) Run the equipment off the mains supply and balance the bridge with the leads as in (c). Switch S3 to 'inductance' and rotate the inductance dial to obtain full scale deflection on the meter. The dial should not have to be rotated more than 5% of full scale.

(m) After a soak test, recheck all ranges at zero, half- and full-scale where possible.

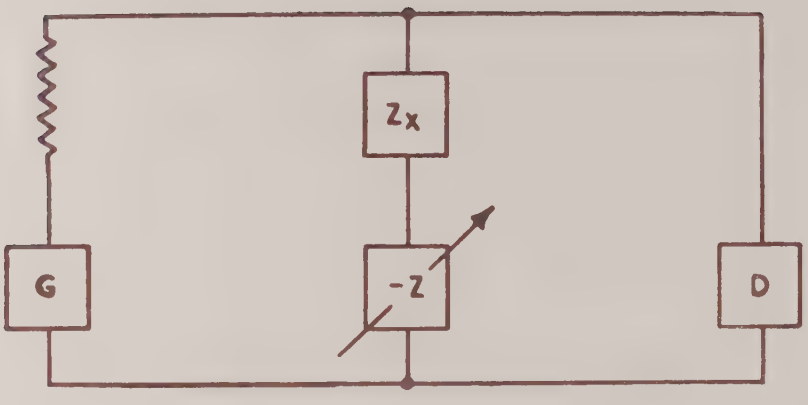


FIG. 1

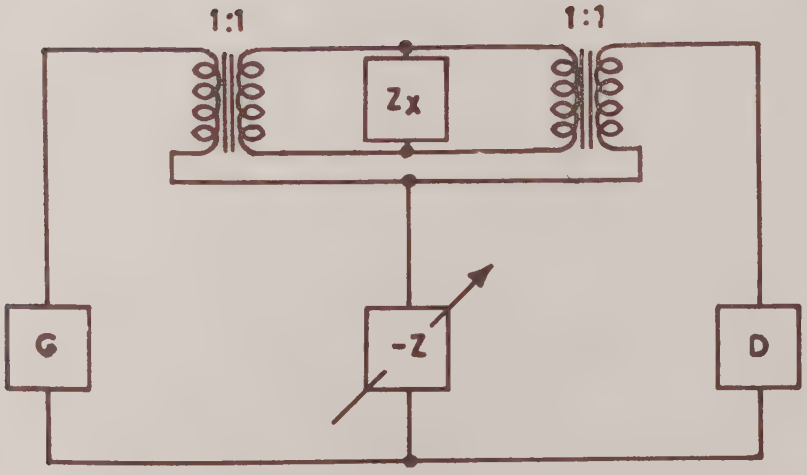


FIG. 2

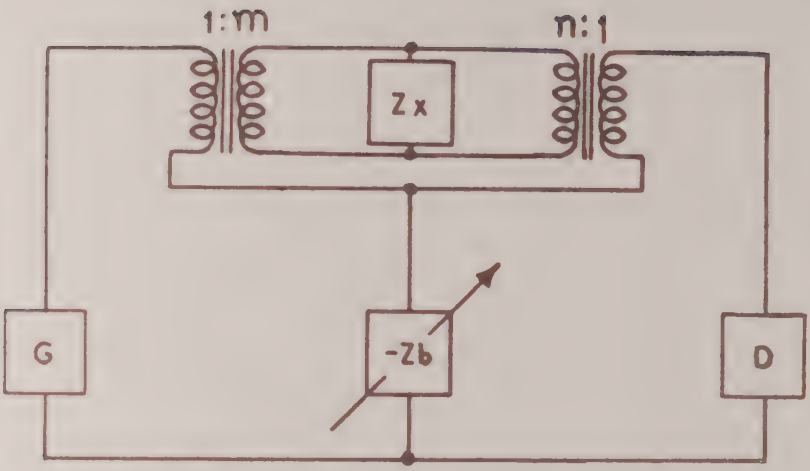


FIG. 3

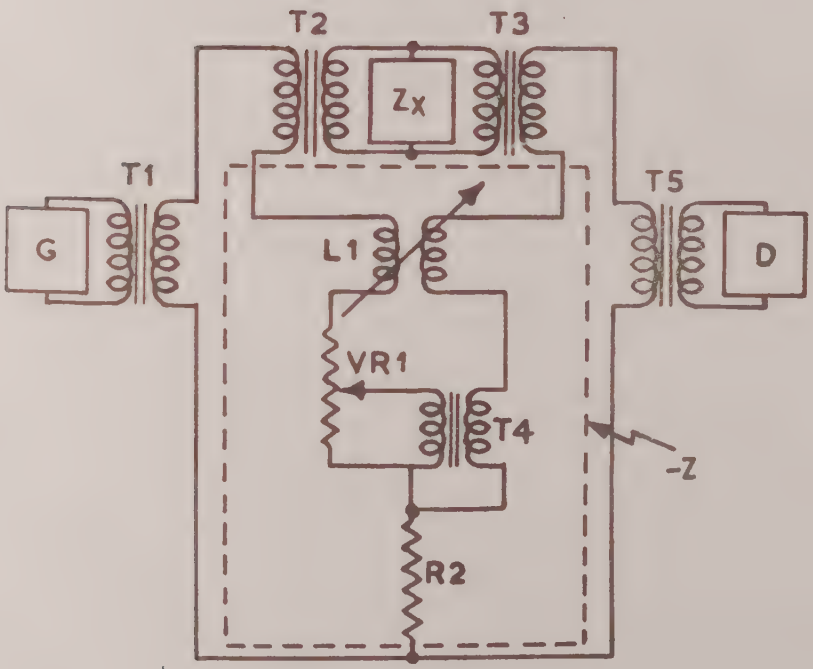


FIG. 4

FIGS. 5,6 & 7

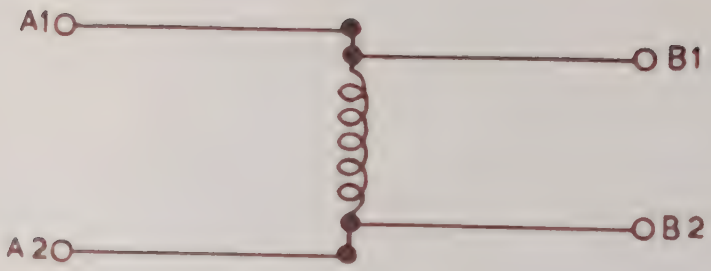


FIG. 5

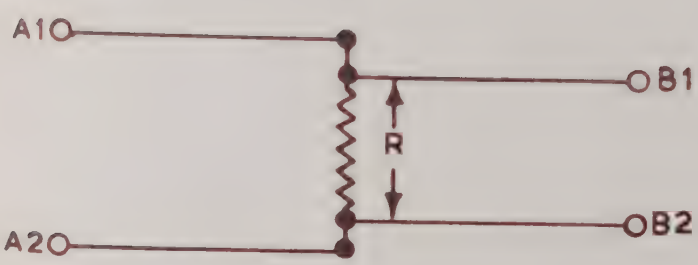


FIG. 6

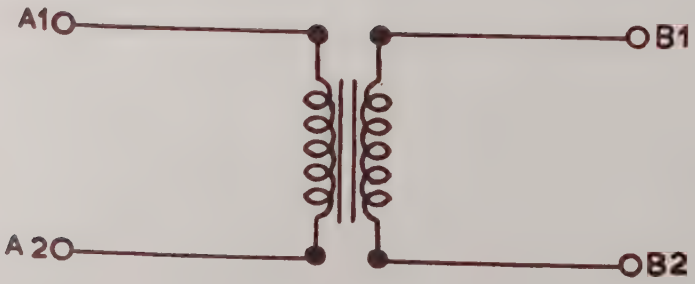


FIG. 7

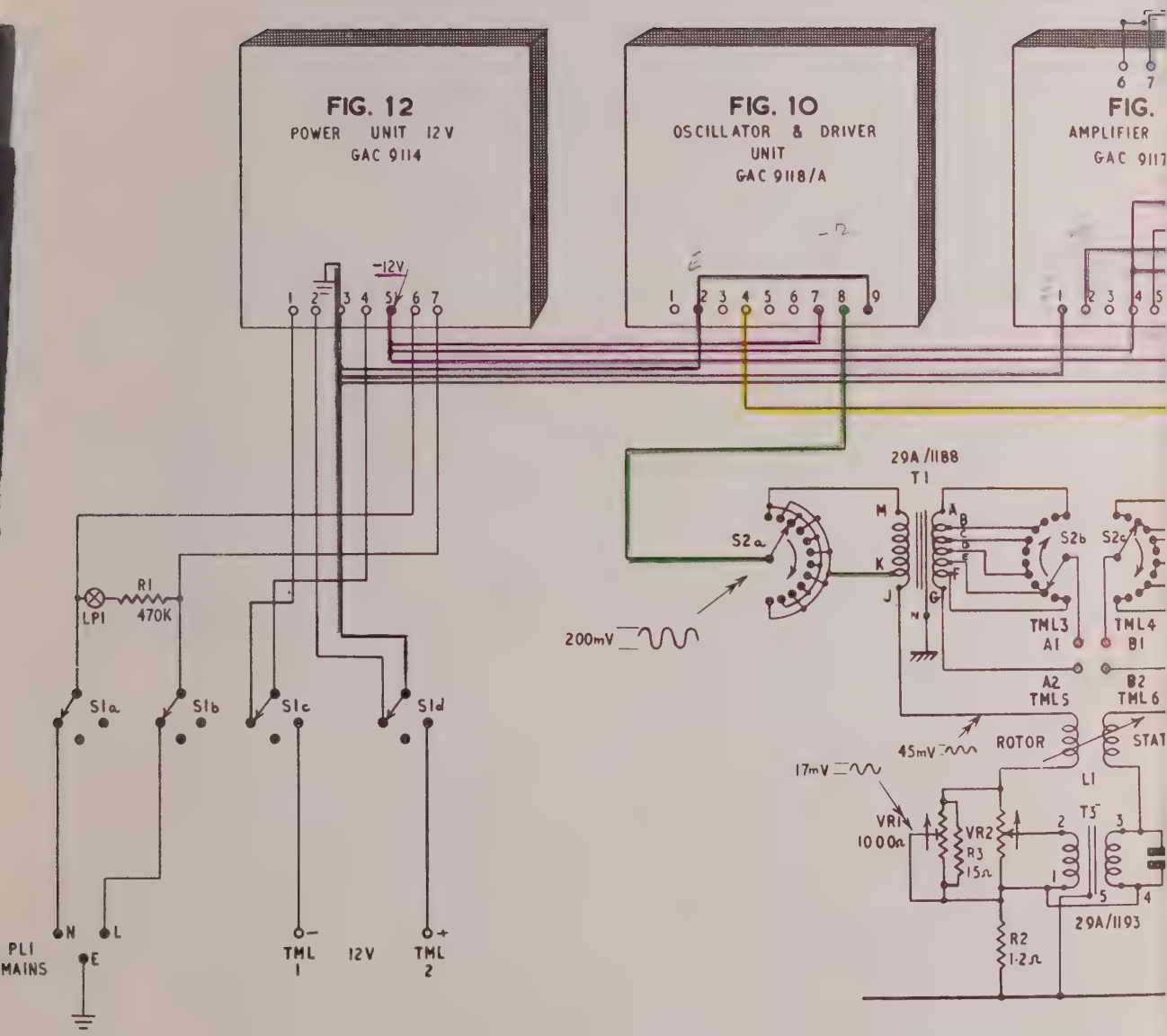


FIG. 12
POWER UNIT 12 V
GAC 9114
FIG. 10
OSCILLATOR & DRIVER
UNIT
GAC 9118/A
FIG.
AMPLIFIER
GAC 911
-12V
29A/1188
T1
S2a
S2b
S2c
200mV
R1
470K
LP1
S1a
S1b
S1c
S1d
TML3
A1
TML4
B1
A2
TML5
B2
TML6
45mV
ROTOR
STAT
17mV
L1
VR1
1000Ω
VR2
R3
15Ω
T3
R2
1·2Ω
29A/1193
PL1
MAINS
N
L
E
TML
1
12V
TML
2

FIGURE

COMPONENTS FOR FIGURE 8

CAPACITORS

C1	·005µF	1000V	PAPER
C2	(100-400pF		No.10 DTS CYLDON
	(15 - 100pF		No.10 DTS CYLDON
C3	15 - 100pF		No.10 DTS CYLDON
C4	(100-400pF		No.10 DTS CYLDON
	(15 - 100pF		No.10 DTS CYLDON
C5	100-400pF		No.10 DTS CYLDON
C6	100-400pF		No.10 DTS CYLDON
C7	100-400pF		No.10 DTS CYLDON
C8	(100-400pF		No.10 DTS CYLDON
	(15 - 100pF		No.10 DTS CYLDON
C9	15 - 100pF		No.10 DTS CYLDON

RESISTORS

R1	470kΩ	1/4W	±10%
R2	1·2Ω	1/4W	±10%
R3	15Ω	1/2W	±1%

TRANSFORMERS

T1	29A/1188
T2	29A/1189
T3	29A/1193

POTENTIOMETERS

VR1	1000Ω	WW	CLR4001/11
VR2	SAC9165/A		

METER

M1	23A/3133

TERMINALS

TML1	PAINTON	312038	BLACK
TML2	PAINTON	312038	RED
TML3	B/LEE	L1318	RED
TML4	B/LEE	L1318	RED
TML5	B/LEE	L1318	BLACK
TML6	B/LEE	L1318	BLACK

SWITCHES

S1	23A/3134
S2	23A/3135
S3	23A/3136

PLUG

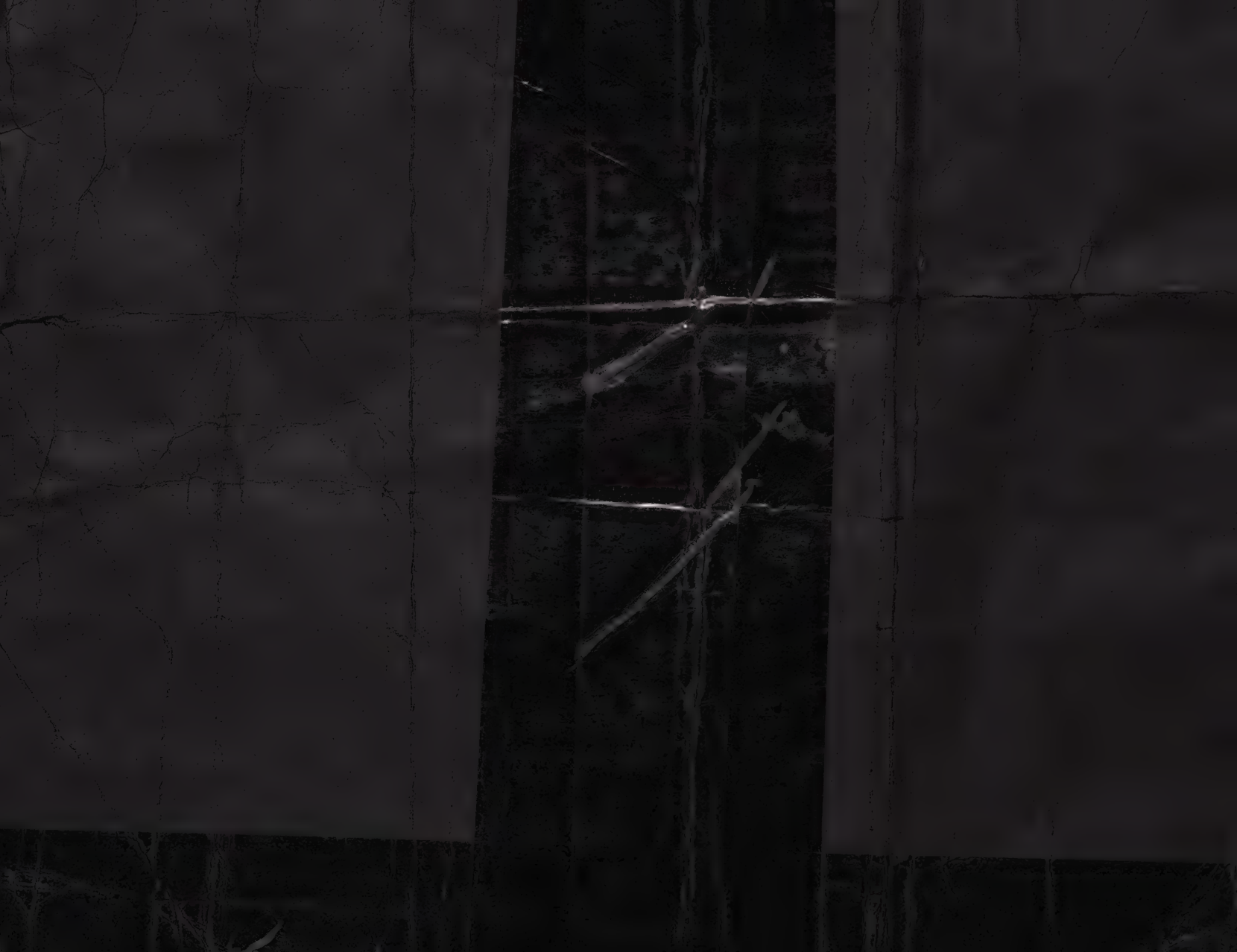
PL1 BULGIN P360

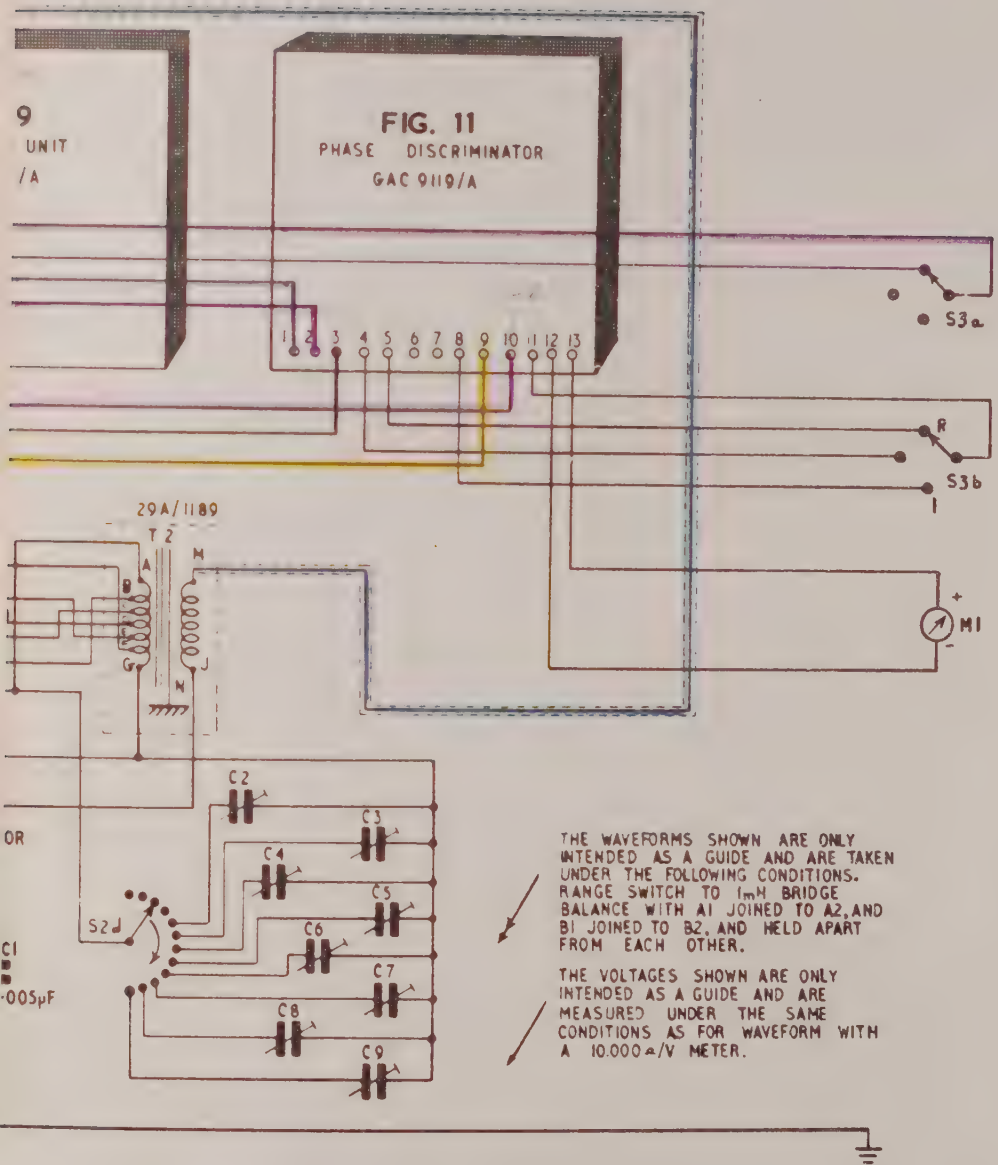
INDUCTOR

L1 SAC 9164/A

LAMP

LP1 NEON M.B.C. GEC. TYPE G





E 8 INDUCTANCE BRIDGE. CINTEL Nº 31C/3951.

THE WAVEFORMS SHOWN ARE ONLY INTENDED AS A GUIDE AND ARE TAKEN UNDER THE FOLLOWING CONDITIONS.
RANGE SWITCH TO 1 mH BRIDGE BALANCE WITH A1 JOINED TO A2, AND B1 JOINED TO B2, AND HELD APART FROM EACH OTHER.

THE VOLTAGES SHOWN ARE ONLY INTENDED AS A GUIDE AND ARE MEASURED UNDER THE SAME CONDITIONS AS FOR WAVEFORM WITH A 10,000 Ω/V METER, WITH RESPECT TO PIN 6.

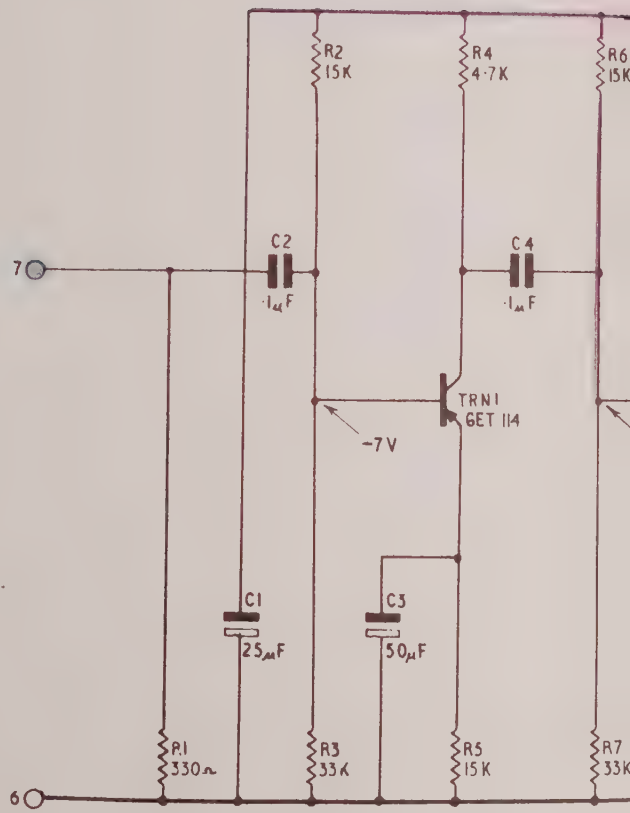
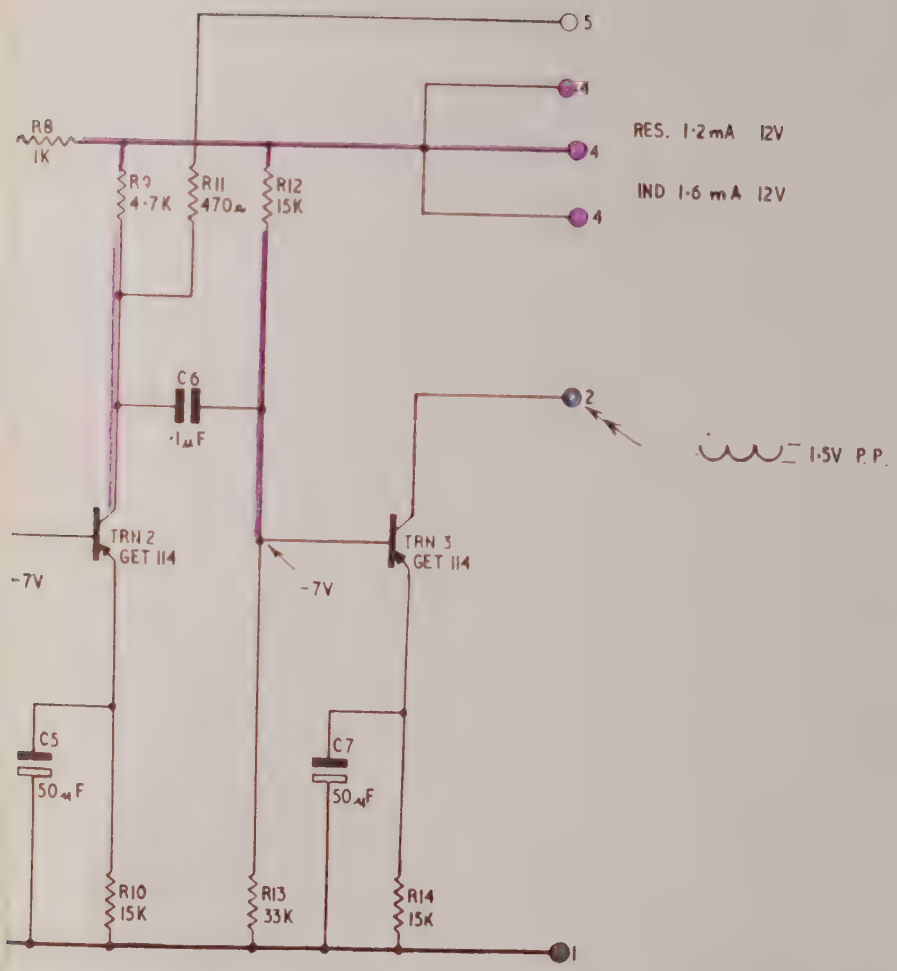


FIGURE 9



BRIDGE AMPLIFIER.

CINTEL

Nº 31C/3941

COMPONENTS FOR FIGURE 10

RESISTORS

R1	470Ω	1/2W	±5%
R2	6·8kΩ	1/2W	±5%
R3	4·7kΩ	1/2W	±5%
R4	3·3kΩ	1/2W	±5%
R5	10kΩ	1/2W	±5%
R6	15kΩ	1/2W	±5%

CAPACITORS

C1	25µF	25V	ELECT.
C2	50µF	6V	ELECT.
C3	·1µF	125V	POLYST.
C4	·1µF	125V	POLYST.

TRANSISTORS

TRN1	GET 114
TRN2	GET 114

TRANSFORMER

T1	ARDENTE	D214/P/1

CHOKE

L1	29A 3183

THE WAVEFORMS SHOWN ARE ONLY INTENDED AS A GUIDE AND ARE TAKEN UNDER THE FOLLOWING CONDITIONS.
RANGE SWITCH TO 1mH BRIDGE BALANCE WITH A1 JOINED TO A2, AND B1 JOINED TO B2, AND HELD APART FROM EACH OTHER.

THE VOLTAGES SHOWN ARE ONLY INTENDED AS A GUIDE AND ARE MEASURED UNDER THE SAME CONDITIONS AS FOR WAVEFORM WITH A 10,000 Ω/V METER, WITH RESPECT TO PIN 2.

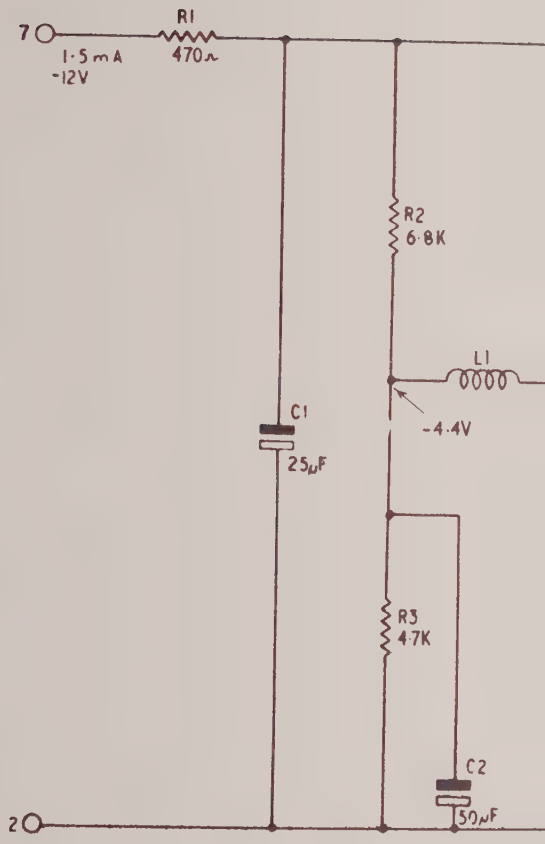
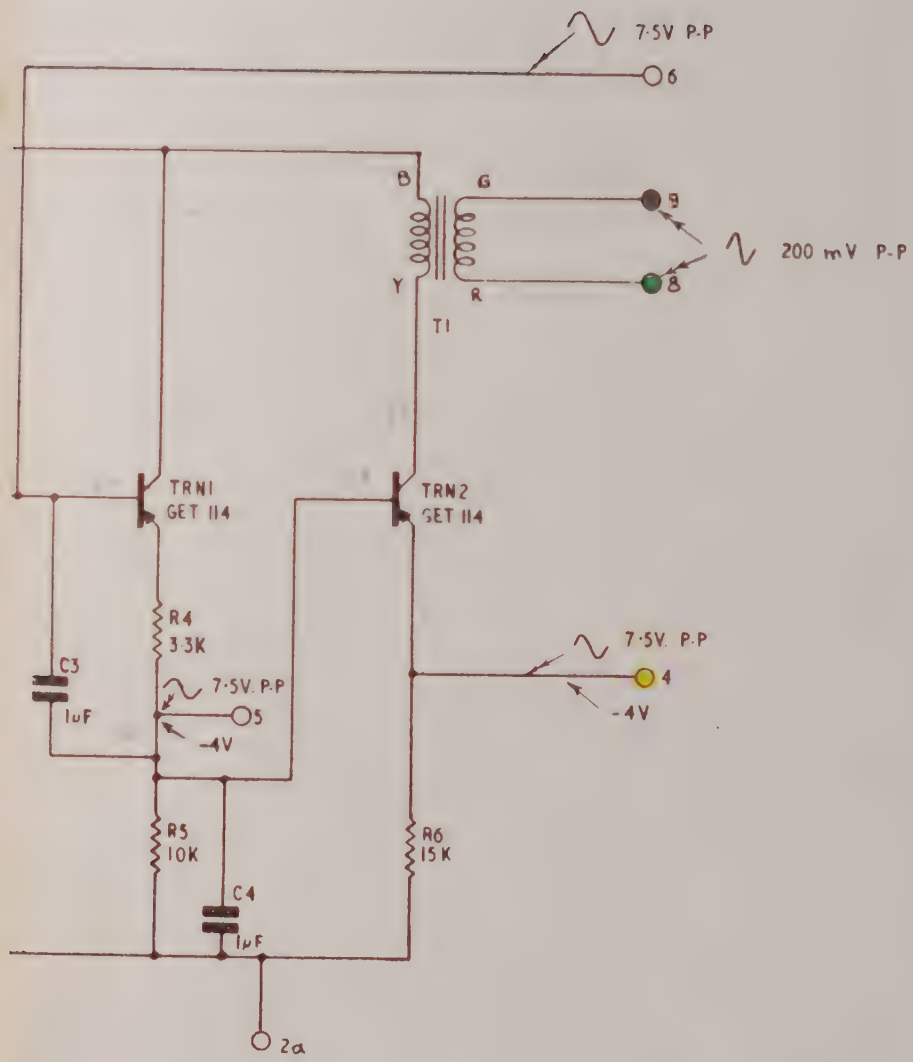


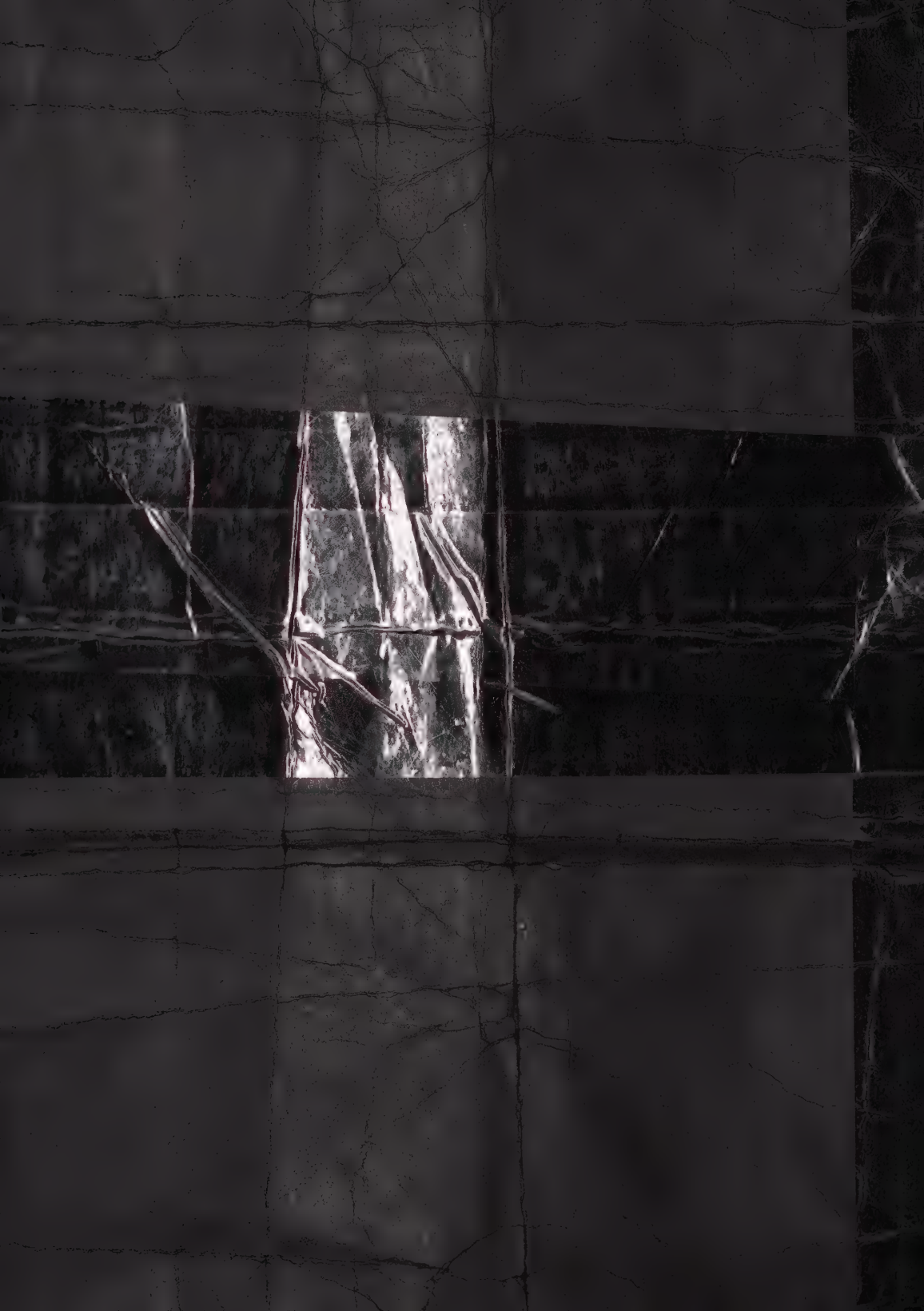
FIGURE 10 OSCI



LATOR & DRIVER.

CINTEL

Nº 31C/3943



COMPONENTS FOR FIGURE 11

RESISTORS

R1	4·7kΩ	1/2W	±5%
R2	6·8kΩ	1/2W	±5%
R3	4·7kΩ	1/2W	±5%
R4	10kΩ	1/2W	±5%
R5	3·3kΩ	1/2W	±5%
R6	1kΩ	1/2W	±5%
R7	1kΩ	1/2W	±5%
R8	1kΩ	1/2W	±5%
R9	1kΩ	1/2W	±5%
R10	470Ω	1/2W	±5%

POTENTIOMETERS

VR1	33kΩ	MP	PRESET
VR2	33kΩ	MP	PRESET

TRANSISTORS

TRN1	GET 114
TRN2	GET 114

CAPACITORS

C1	50µF	6V	ELECT.
C2	4µF	12V	ELECT.
C3	·01µF	500V	PAPER
C4	·01µF	500V	PAPER
C5	50µF	6V	ELECT.
C6	4µF	12V	ELECT.
C7	4µF	12V	ELECT.
C8	25µF	25V	ELECT.

TRANSFORMERS

T1	ARDENTE	D363/P/1
T2	ARDENTE	D363/P/1
T3	ARDENTE	D105/P/1

RECTIFIERS

MR1	OA10
MR2	OA10

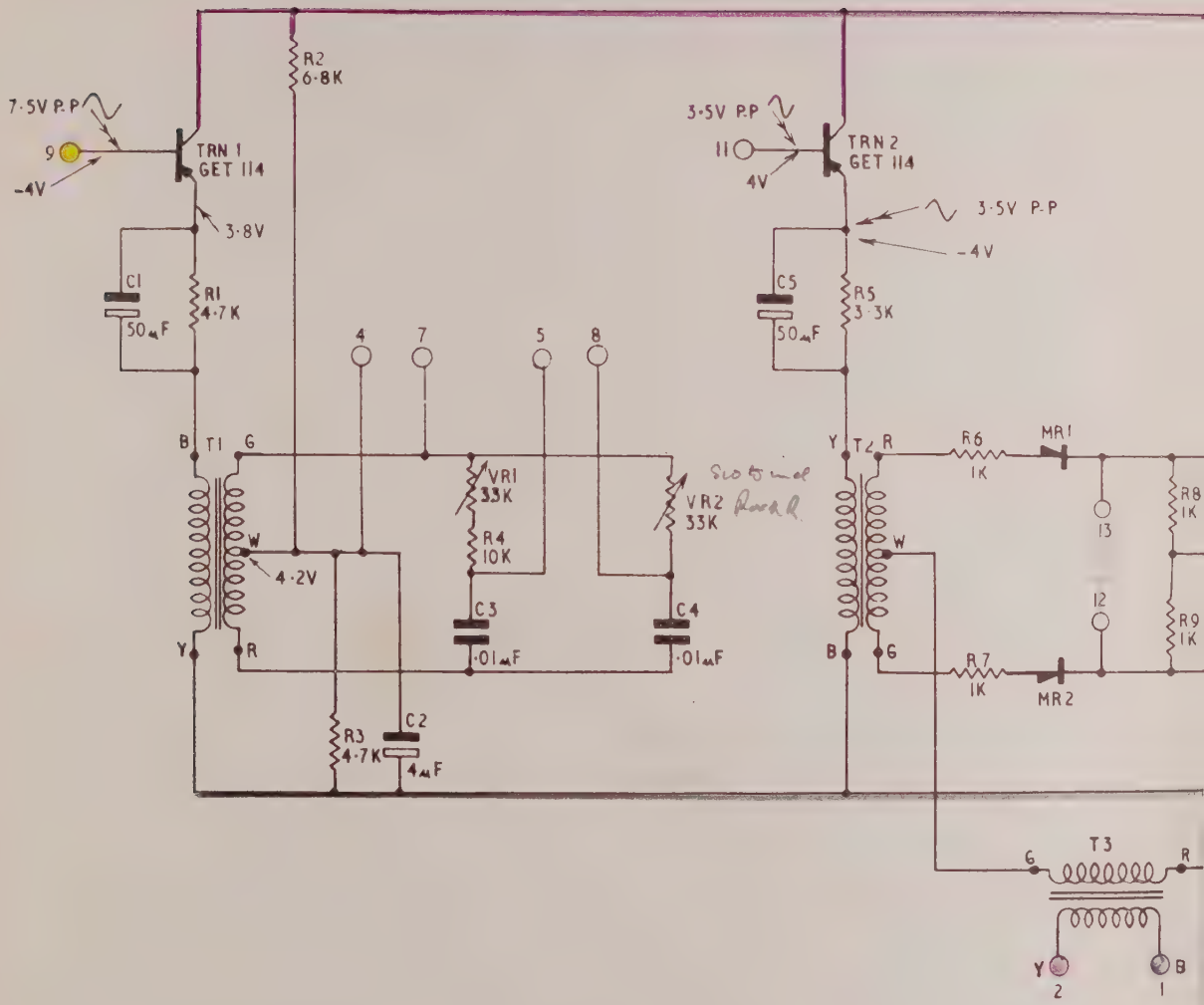
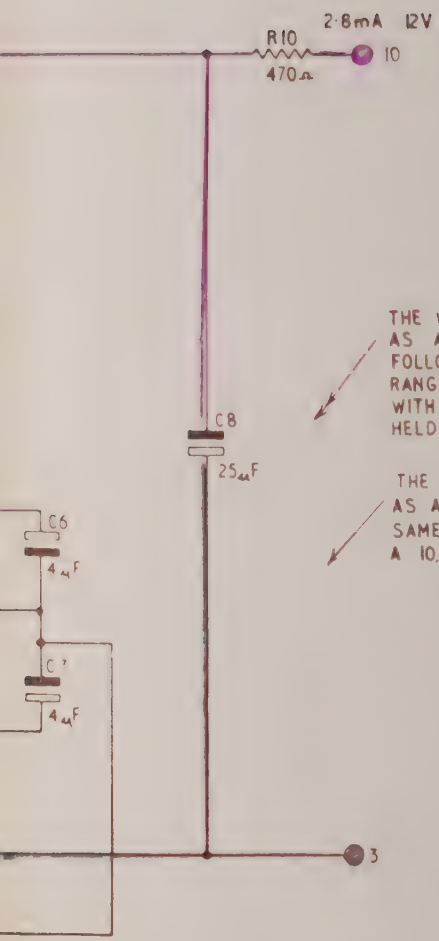


FIGURE 11 PHASE DISCRIM

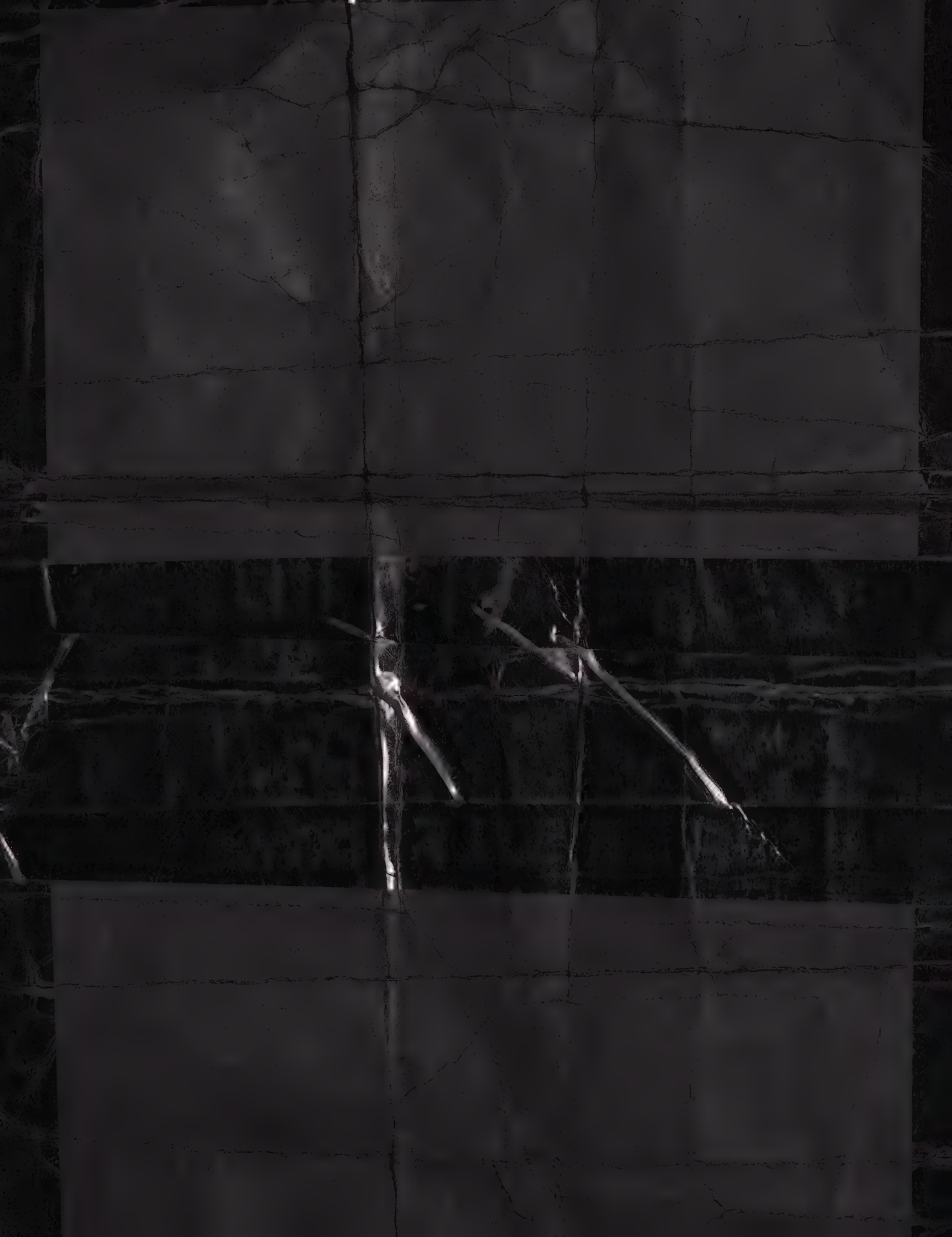


THE WAVEFORMS SHOWN ARE ONLY INTENDED AS A GUIDE AND ARE TAKEN UNDER THE FOLLOWING CONDITIONS.
RANGE SWITCH TO 1mH BRIDGE BALANCE WITH A1 JOINED TO A2, AND B1 JOINED TO B2, AND HELD APART FROM EACH OTHER.

THE VOLTAGES SHOWN ARE ONLY INTENDED AS A GUIDE AND ARE MEASURED UNDER THE SAME CONDITIONS AS FOR WAVEFORM WITH A 10,000Ω/V METER, WITH RESPECT TO PIN 3.

IINATOR.

CINTEL Nº 31C/3945



COMPONENTS LIST FOR FIGURE 12

RESISTOR

R1	1kΩ	1/2W	±10%

CAPACITOR

C1	50μF	50V	ELECT.

DIODES

MR1	OA81	MULLARD
MR2	OA81	MULLARD
ZD1	SX62	G.E.C.
ZD2	SX62	G.E.C.

FUSES

F1	100mA	SIZE 00	B/LEE	L562
F2	100mA	SIZE 00	B/LEE	L562

TRANSFORMER

T1	23A/3153

PLUGS

PL1	SAA 9241
PL2	SAA 9241

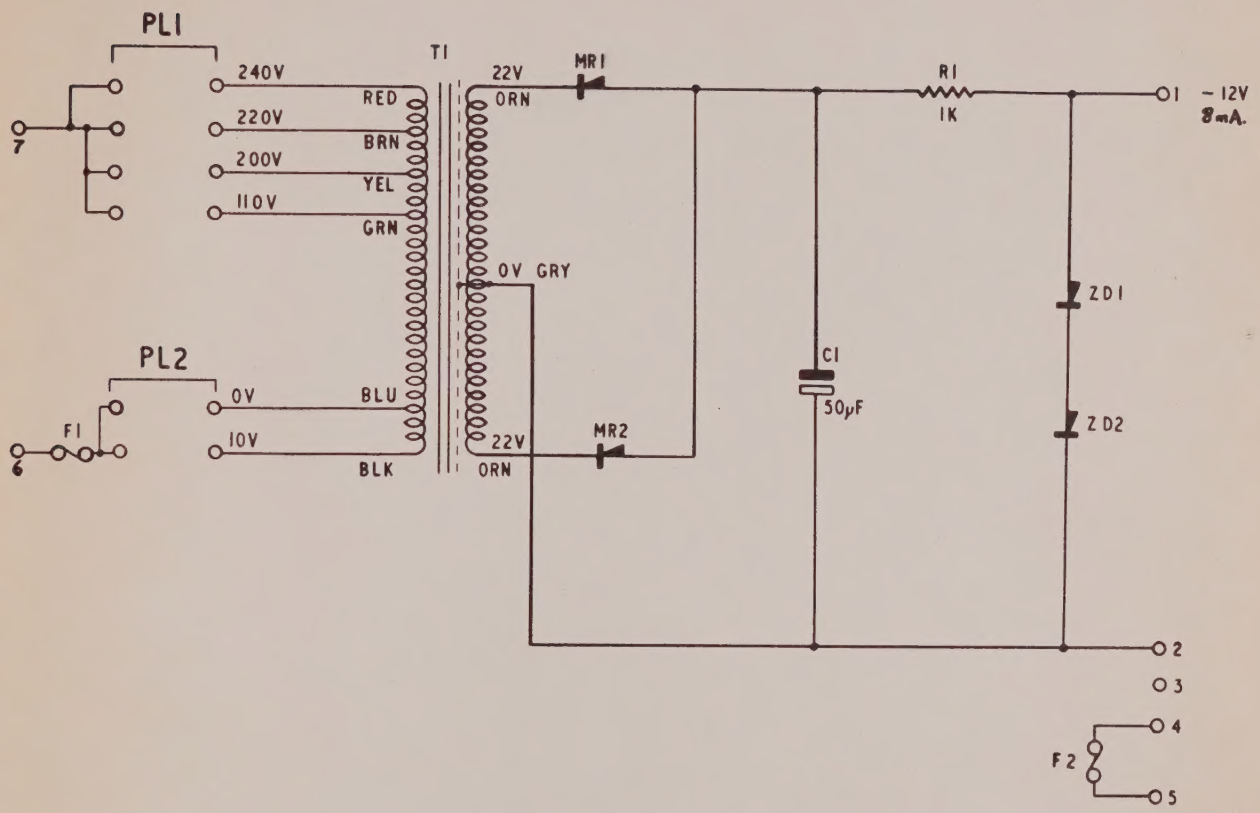


FIGURE 12 POWER UNIT.

CINTEL Nº 31C/3947.

RankCintel

a division of the Rank Organisation

The Rank Organisation
Rank Cintel Division
Worsley Bridge Road Lower Sydenham
London SE26 England

MP MASTER

MA23809

As 'Cintel' equipment is under constant review to bring about improvements in design, a unit supplied may differ in minor detail from that described.